SPECIES COMPOSITION IN THE JAPANESE LONGLINE FISHERY OFF THE SOUTHERN AND EASTERN UNITED STATES

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SUMMARY

The species composition and the catch rates of each species are examined for the Japanese longline fishery operation in the Gulf of Mexico and off the Southeastern and Northeastern United States. The data were collected by U.S. observers aboard the vessels that fished in the U.S. Fishery Conservation Zone. The data sets examined were those of 1978, 1979 and 1980. Yellowfin tuna and sharks were important in the Gulf of Mexico and the southeastern part of the West Atlantic, ranging from 37 percent to 41 percent and from 9 percent to 15 percent respectively of the total number of fish caught. In the northeastern part of the West Atlantic, bigeye tuna (18 percent to 20 percent), albacore (13 percent to 31 percent), and sharks (13 percent to 27 percent) comprised the catches. Bluefin tuna catches (25 percent) were important in the Gulf of Mexico. White marlin and swordfish were important species among the billfishes. The changes in percent of species composition in sets with high and low catch rates are discussed, as well as inter-species associations among the main species caught, with respect to co-occurrences in sets. Most species were caught at rates of less than 10 fish per 1000 hooks.

RESUME

La composition par espèces et le taux de capture de chacune d'entre elles sont examinées dans le cas des palangriers japonais pêchant dans le golfe du Mexique et au large des côtes du sud-est des Etats-Unis. Les données ont été rassemblées par des observateurs américains à bord des bateaux qui ont pêché dans la "Fishery Conservation Zone" des Etats-Unis. Les jeux de données étudiés sont ceux de 1978, 1979 et 1980. L'albacore et les requins sont importants dans le golfe du Mexique et le sud-est de l'Atlantique ouest, représentant respectivement 37-41 % et 9-15 % de la prise numérique totale. Les prises du nord-est de l'Atlantique ouest sont caractérisées par la présence de thon obèse (18-20 %), de germon (13-31 %) et de requins (13-27 %). Le thon rouge (25 %) est important dans le golfe du Mexique. Parmi les poissons porte-épée, le makaire blanc et l'espadon prédominent. Les modifications de la composition par espèce en pourcentage entre opérations présentant un taux de capture médiocre ou élevé sont examinées, ainsi que les associations entre les principales espèces capturées en ce qui concerne leur présence conjointe dans les opérations. La plupart des espèces ont été capturées à un taux inférieur à 10 poissons par millier d'hameçons.

RESUMEN

Se estudia la composición por especies y las tasas de captura de cada especie en las operaciones de la pesquería japonesa de palangre en el Golfo de México y frente a las costas Sudeste y Nordeste de Estados Unidos de América. Los datos fueron recopilados por observadores norteamericanos embarcados en unidades que faenaban en la Zona de Conservación de Pesquerías (FCZ) de ese país. Se examinaron los conjuntos de datos de 1978, 1979 y 1980. Una parte importante de la captura obtenida en el Golfo de México y área sudoriental del Atlántico Oeste estuvo compuesta por ejemplares de rabil y tiburón , oscilando el número total de peces capturados de 37%-41%, y de 9%-15% respectivamente. En el área noroeste del Atlántico Oeste, las capturas estuvieron compuestas principalmente por patudo (18%-20%), atún blanco (13%-31%) y tiburón (13%-27%). El atún rojo abundó en el Golfo de México (25%). Entre los marlines, había cantidades importantes de aguja blanca y pez espada. Se discuten los cambios en los porcentajes de la composición por especies en los lances con capturas abundantes y escasas, y las asociaciones entre las especies más importantes de la captura, respecto a la simultaneidad de los lances. La mayor parte de las especies fueron capturadas en proporciones inferiores a 10 peces por 1000 anzuelos.

Introduction

Since 1978 the Pascagoula Laboratory of the National Marine Fisheries Service, Southeast Fisheries Center, has placed observers aboard Japanese long-liners fishing within the 200-mile limit of the Fishery Conservation Zone (FCZ) of the United States. These observers monitor fishing activities and gather scientific information for this fishery, which operates in the Gulf of Mexico and off the Southeastern and Northeastern United States. Tunas are the target species of this fishery.

The physical characteristics of the Japanese long-line fishery operating off the U.S. have previously been described (Anonymous 1979[1]). Briefly, vessels averaging 49.8 m length and 350 tons gross weight set out long-line gear between 74 and 137 km (40-70 mi) in length and containing approximately 2200 hooks that drop approximately 40 m from the surface. The gear is usually set between 0300 and 0600 hours in the morning. Haulback begins between 0100 and 1300 hours. Soaking time is about 12 hours. A summary of gear characteristics from the sets examined in this paper is given in Table 1.

Catch composition and catch rates have previously been described for this fishery (Reese 1983, Thompson 1982). These authors provided detailed descriptions of the spatial distribution of effort, observer coverage, catch and catch rates by species. Observer coverage was better than 20% of the fishing days within the FCZ, the stated goal of the program, and was proportional to total fishing effort.

In this paper the species composition is reviewed in somewhat more detail. All species caught by the Japanese long-line gear are examined. Additionally the effect of catch rate on species composition, the evidence for species interactions or associations, and the distribution of size of fish caught by species, are discussed.

Methods

Observer data collected during 1978, 1979, and 1980 were examined. The records were obtained from the Southeast Fisheries Center. Records from individual sets containing information on species caught, size of specimens, and number of hooks per set were summarized according to fishing area, year, season, and catch rate. The latter statistic was calculated from the catch of all tunas, and expressed as catch per 1000 hooks. The frequency of co-occurrence on the same sets of various species pairs was tabulated for each fishing area, combining the data for the years 1978-1980. These data were re-arranged to form 2X2 presence-absence, association tables to test for evidence of species interactions (Pielou 1969). Fork length of fish was recorded in cm (measured from the tip of the lower jaw in the case of billfish). These data were summarized in the form of size-frequency tables.

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[1]Anonymous. 1979. Southeast Foreign Fishery Observer Project. National Marine Fisheries Service, SEFC, Pascagoula Laboratory. Briefing Document.

Data will be presented separately for FCZ zones 12-14 off the southern U.S. in the Gulf of Mexico, FCZ zone 15 off the Southeastern U.S. between Florida and Cape Hatteras, and FCZ zones 16-17 off the Northeastern U.S., north of Cape Hatteras. For brevity these areas will be called Gulf of Mexico, Southeastern U.S., and Neartheastern U.S., respectively.

Results

Species Caught

The names of species caught on the long-lines are given in tables 2, 3, and 4, for tunas and other main species or species groups, for sharks, and for "other fish," respectively. Each species is referenced by a number code which will be referred to in subsequent tables. Not included are the dolphins (Family Delphinidae) of which only 18 were reportedly caught. The species were the bottlenose dolphin (*Tursiops truncatus*), pilot whale (*Globicephala sp.*), and false killer whale (*Pseudorca crassidens*).

Catch Rates

Catch rates tended to be highest in the 1st to 3rd quarters of the year in the Gulf of Mexico and highest during the 3rd and 4th quarters off the Southeastern and Northeastern U.S. Presumably this reflects seasonal movements of tuna and the fleet fishing these tuna. Because of changes in effort by area, year, and season, it is difficult to compare quarterly values of catch rate. In Table 5, the catch per 1000 hooks are pooled for each year for the Gulf of Mexico, the Southeastern U.S., and the Northeastern U.S. These data are shown for the three main categories of fish: tunas, billfishes, and sharks. The most frequent catch rate of tunas, as a group, fell between 5 and 10/1000 hooks in the Gulf of Mexico and between 10 and 20/1000 hooks in the Atlantic. Billfish and sharks were most frequently caught at rates 1-5/1000 hooks in all areas.

Species Composition

The percentage of each species or species group caught are presented in Tables 6, 7, and 8 for the Gulf of Mexico, Southeastern U.S., and Northeastern U.S. respectively. The data are arranged according to intervals of tuna catch rate and for the first and second halves of the year, for the combined 1978-1980 years. The semi-annual partitioning was chosen to correspond with the major shifts in the fishery.

Tables 6-8 shows that eight species or species groups were numerically important in the aggregate of catches. With the exception of bluefin tuna, this was true regardless of area. Bluefin tuna (Code 1) amounted to 25% of all fishes caught in the Gulf of Mexico, but its catch was negligible elsewhere. Bigeye tuna (Code 2) amounted to 17%-20% of the catches in the Northeastern U.S., but was 5%-9% elsewhere. Yellowfin tuna (Code 3) was most important in the Gulf and the Southeastern U.S., where its catches comprised more than 30% of the total. Yellowfin tuna catches were < 20% off the Northeastern U.S. Albacore (Code 5) catches were most important in the Atlantic areas, amounting to 10%-31% of the long-line catches there. White marlin (Code 11) catches amounted to 3%-5% of the total and swordfish (Code 14) amounted to 1%-3% of the total numerical catch. Sharks comprised

9%-10% of the catch in the Gulf, and 13%-27% in the Atlantic. Other species of fish amounted to 14%-28% of the total catch in the different areas.

It had been anticipated that the species composition of the catches would change with the catch rate, i.e., with the richness of fishing localities. However no trends in composition were evident in the breakdown by catch rate, other than the decline in percentage of non-tuna species, especially sharks and "other fishes," as tuna catch rates increased. In the Gulf of Mexico the increase in the catch rate of tunas was due to bluefin and yellowfin during the first half of the year and to yellowfin and albacore during the second half, when bluefin were infrequently caught. In both cases the percentage of sharks, swordfish, and "other fish" decreased concurrently. In the Southeastern U.S. the data indicated that substantial catches occurred only during the second half of the year. The increase in tuna catch rate then was due to bigeye and yellowfin tuna at moderate catch rates but almost entirely to yellowfin at high catch rates (catch/1000 hooks > 20). Off the Northeastern U.S. bigeye and especially albacore tuna increased with catch rate as other species declined during the first half of the year. During the second half, bigeye tuna decreased at higher catch rates as both albacore and yellowfin tuna continued to increase in percentage of the total catch.

Sharks and "other fish" comprised a relatively large percentage of the total long-line catch in numbers. The percentage of these two groups can each be larger than that of any of the tuna species, depending upon area and season (Table 9). In all three regions blue sharks (Code 24) were the most important component species, percentage-wise. In the Gulf of Mexico and off the Southeastern U.S. the white-tip (Code 22), thresher (Code 28), and mako sharks (Code 27) also occurred regularly. The mako was also relatively important in the northeast. Among the "other fish," the lancet fish (Alepisaurus sp.) and sting rays (Code 47) were the conspicuously important component species in all three areas.

Interspecies Associations

Bigeye, yellowfin, and albacore tuna, white marlin and swordfish, and the ubiquitous sharks seem to be characteristic of the long-line catches. It is therefore of some interest to ask if some of these species tend to be associated, to assess the likelihood of joint catches of certain species on the same long-line set. This was investigated by first summing the numbers of sets in which each combination of a species pair were both caught. These data are shown in Table 10 for the three fishing areas and for the various combinations of 11 species, including the sharks. These data were then re-arranged to form 2X2 presence-absence association tables (see footnote Table 10 for example). The evidence for interaction or association in these tables was tested using the Chi-square test with d.f. = 1. Since all combinations of these species were tested, one must accept the reality of an apparent significant test value with caution, for the chance of committing a Type-1 statistical error is increased under the circumstances. To reduce this possibility, only significance levels of $P < 0.01$ were used. The numbers of co-occurrences of species pairs in Table 10 are marked with an (*) when they correspond to a significant association, and a (-*) when the association is negative.

Many species pairs were found to occur on sets together in combinations that indicated associations, both positive and negative. A pattern in these associations, from area to area, was not apparent. The interactions are either very complex or revealing of sampling problems. Perhaps a long-line set 60 miles long should not be considered a sample for species association. Only a few generalities seem warranted at this time. In the Gulf of Mexico yellowfin tuna appeared associated with the various billfish, but not with swordfish. Albacore appeared associated with bigeye tuna, sharks, and spearfish, but again not swordfish. Bluefin tuna appeared to be negatively associated with most other tunas and billfish. Perhaps this latter reflects special fishing tactics employed for bluefin. Off the Southeastern U.S. yellowfin and albacore tuna appeared positively associated with the various billfish including, as in the Gulf of Mexico, the white marlin. Swordfish were negatively associated with most other species. Off the Northeastern U.S. yellowfin tuna seemed associated with albacore and white marlin. Sharks were positively associated with albacore in the Gulf of Mexico and off the Northeastern U.S. but not with most other fish including the other tunas. This seemed surprising, considering that most set do catch sharks. It must be remembered however that for a positive association, two species must both occur together sometimes and not occur together sometimes more frequently than would be expected by chance.

Discussion

The 1978-80 Japanese long-line fishery in the FCZ in the Gulf of Mexico and off the Southeastern and Northeastern United States caught a wide variety of fishes, but primarily tunas and sharks. Yellowfin and bigeye tunas were the principle species sought, with bluefin also important in the Gulf of Mexico and albacore in the northeast. Sharks, primarily the blue shark, were caught almost as frequently as were some of the tunas, occuring on 84% of the Gulf of Mexico sets and 99% of Atlantic sets. Surprisingly there was little evidence that sharks, as a group, were positively associated with the presence of tuna species on the same sets. Rather these common predators appear to be caught randomly with the tunas. It was noted during this study that catches were very variable among species in different years and quarters of the year (data not shown) suggesting a changing, non-equilibrium fishery. Whereas in 1978 some fishing occurred in all quarters of the year in the Gulf of Mexico and primarily during the last two quarters off the Northeastern U.S., by 1980 both these areas were fished in all quarters.

It should be kept in mind that this was a long-line fishery for tunas. Tunas are not managed under the Fishery Conservation and Management Act which established the FCZ. However billfishes and other species for which there is not an applicable national allocation are prohibited species. Specifically all billfishes and sharks (unless there is a Shark Permit) must be released. The species composition of the catches must reflect, in part, these aims and constraints.

One intention of this study was to examine the distribution of caught fish on gear, as a function of catch rate. This could be informative with regard to possible effects that exploitation might have on the re-distribution of fish or school size. That information was not obtainable for this study, but would be worth pursuing in the future.

Literature Cited

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Table 1. Characteristics of long-line gear from observer-sampled sets.

	1978, n=392		1979, n=494		1980, n=491	
	$\bar{x}$	s	$\bar{x}$	s	$\bar{x}$	s
Length (km)	77.2	94.4	74.6	30.0	66.1	46.7
Hooks	2163.3	302.8	2258.0	244.0	2179.4	394.0
Floats	441.9	87.8	474.0	86.4	388.4	105.2
Hook Depth (m)	41.4	6.3	42.3	14.2	44.4	13.4
Soak hours	12.4	1.5	12.2	1.9	12.3	2.1

Table 2. Names of main species caught on long-lines.

Code	Common	Scientific
1	Bluefin Tuna	Thunnus thynnus
2	Bigeye Tuna	Thunnus obesus
3	Yellowfin Tuna	Thunnus albacares
4	Skipjack Tuna	Katsuwonus pelamis
5	Albacore Tuna	Thunnus alalunga
6-9	Small/other Tuna	-
10	Blue Marlin	Makaira nigricans
11	White Marlin	Tetrapturus albidus
12	Sailfish	Istiophorus platypterus
13	Spearfish	Tetrapturus sp.
14	Swordfish	Xiphias gladius
19	Unidentified Billfish	Istiophoridae
20-38, 90-93	Sharks	-
40	Dolphin fish	Coryphaena sp.
41	Wahoo	Acanthocybium solanderi
42-59	Other fish	-
60-65	Turtle	-

Table 3. Names of sharks caught on long-lines.

Code	Common	Scientific
20	Silky	Carcharhinus falciformes
21	Blacktip	Carcharhinus limbatus
22	Whitetip	Carcharhinus longimanus
23	Dusky	Carcharhinus obscurus
24	Blue	prionace glauca
25	Tiger	Galeocerdo cuvieri
26	Hammerhead	Sphyrna sp.
27	Mako	Isurus sp.
28	Thresher	Alopias sp.
29	Unidentified	-
30	Porbeagle	Lamna nasus
31	Brown	Carcharhinus plumbeus?
32	Spiny Dogfish	Squalus acanthias
33	Dogfish	Squalidae
34	Bignose	Carcharhinus altimus
35	Lemon	Negaprion brevirostris
36	Shortfin	Isurus sp.
37	Longfin Mako	Isurus paucus
38	Bigeye Thresher	Alopias superciliosus
90	Nurse	Ginglymostoma cirratum
91	Atl. Sharpnose	Rhizoprionodon terraenovae
92	Bull	Carcharhinus leucas
93	Seven-gill	Otorynchus maculatus

Table 4. Names of "other fishes" caught on long-lines.

Code	Common	Scientific
40	Dolphin	Coryphaena sp.
41	Wahoo	Acanthocybium solanderi
42	King Mackerel	Scomberomorus cavalla
43	Lancet fish	Alepisaurus sp.
44	Oil fish	Ruvettus pretiosus
45	Ocean Sunfish	Mola-mola
46	Opah	Lampris guttatus
47	Sting Ray	Dasyatidae
48	Barracuda	Sphyraena sp.
49	Unidentified	-
50	Eel	-
51	Amberjack	Seriola sp.
52	Pomfret	Taractichthys sp.
53	Manta Ray	Mobulidae
54	Frigate Mackerel	Auxis sp.
55	Jack Cravelle	Caranx sp.
56	Escolar	Lepidocybium flavobrunneum
57	Puffer	Tetradontidae
58	Remora	Remora sp.
59	Sword Scabbard fish	Trichiuridae

Table 5. Distribution of catch per 1000 hooks among tunas, billfish, and sharks (data are numbers of sets).

Fish/1000 hooks	Gulf of Mexico 1978	1979	1980	Total	Southeastern U.S. 1978	1979	1980	Total	Northeastern U.S. 1978	1979	1980	Total
1. Tunas												
0	3	3	3	9	-	-	1	1	1	-	2	3
1-5	41	140	45	226	3	2	5	10	16	2	28	46
6-10	41	50	32	123	5	9	14	28	24	10	50	84
etc.-20	43	17	42	102	13	13	27	53	43	18	99	160
30	35	-	15	52	15	28	8	51	20	5	37	62
40	12	1	11	24	19	14	10	43	10	2	15	27
50	7	2	2	11	14	3	3	20	1	3	10	14
60	5	2	1	8	6	3	2	11	-	1	2	3
70	1	2	1	4	1	2	-	3	1	-	4	5
80	-	1	1	2	6	1	-	7	-	1	-	1
90	-	1	-	1	-	-	-	-	-	-	-	-
100	-	-	1	1	1	-	-	1	-	-	1	1
>100	2	1	-	4	2	-	-	2	-	-	1	1
2. Billfishes												
0	18	34	11	63	2	-	6	8	13	6	47	66
5	126	169	128	423	59	1	52	912	92	32	191	315
10	37	8	12	57	17	51	12	80	11	3	9	23
20	9	-	2	11	6	16	-	22	-	1	2	3
30	-	-	1	1	1	7	-	8	-	-	-	-
40	-	-	-	-	-	-	-	-	-	-	-	-
50	-	-	-	-	-	-	-	-	-	-	-	-
60	-	-	-	-	-	-	-	-	-	-	-	-
70	-	-	-	-	-	-	-	-	-	-	-	-
80	-	-	-	-	-	-	-	-	-	-	-	-
90	-	-	-	-	-	-	-	-	-	-	-	-
100	-	-	-	-	-	-	-	-	-	-	-	-
>100	-	-	-	-	-	-	-	-	-	-	-	-
3. Sharks												
0	11	55	28	94	-	2	-	2	1	-	3	4
5	114	157	111	382	9	57	38	104	54	6	130	190
10	17	3	14	34	36	11	23	70	31	10	50	91
20	4	4	1	9	25	4	6	35	17	12	34	63
30	1	1	-	2	10	-	1	11	8	8	16	32
40	-	-	-	-	3	1	-	4	-	3	7	10
50	-	-	-	-	-	-	1	1	3	1	4	7
60	-	-	-	-	2	-	1	3	-	2	3	5
70	-	-	-	-	-	-	-	-	1	-	1	2
80	-	-	-	-	-	-	-	-	-	-	-	-
90	-	-	-	-	-	-	-	-	-	-	-	-
100	-	-	-	-	-	-	-	-	-	-	-	-
>100	-	-	-	-	-	-	-	-	-	-	-	-

Table 6. Catch composition (% of total numbers caught) in the Gulf of Mexico, 1978-80 data combined.

Half of year	Spp.	Catch/1000 hooks <5	5-10	>10-20	>20-40	>40	All
1	1	24.5	25.9	32.1	11.7	45.5	24.6
	2	3.6	5.7	5.4	4.3	4.3	4.7
	3	14.4	23.5	27.1	55.6	35.5	30.9
	4	0.3	0.2	-	0.2	-	0.2
	5	-	0.5	1.6	1.4	-	0.8
	6-9	-	0.3	0.3	0.9	0.8	0.4
	10	0.7	1.1	1.0	0.4	0.1	0.7
	11	2.7	3.3	3.2	4.6	3.7	3.5
	12	0.1	0.6	0.2	0.6	0.2	0.4
	13	0.2	0.2	0.1	0.4	0.1	0.2
	14	13.1	11.5	7.1	3.0	1.0	8.2
	19	-	0.2	0.1	0.1	1.1	0.2
	Sharks	14.3	12.1	10.1	5.3	1.4	9.8
	40	0.3	1.8	2.0	0.7	0.5	1.1
	41	0.7	0.6	0.6	0.6	0.4	0.6
	Other fish	25.0	12.2	8.9	10.1	5.3	13.5
	Turtles	0.3	0.2	-	0.1	-	0.2
	n	3045	3294	2716	3293	829	13177
	sets	231	123	60	40	8	462
2	1	-	0.1	-	0.1	-	0.1
	2	0.9	10.4	8.1	9.6	4.4	7.3
	3	-	9.8	28.9	32.0	54.6	37.4
	4	-	0.1	0.3	0.2	0.3	0.2
	5	0.9	5.0	9.8	17.9	10.1	11.7
	6-9	-	1.0	2.3	2.0	0.7	1.5
	10	1.7	0.8	1.1	0.2	0.7	0.7
	11	10.4	5.1	7.4	5.3	3.7	5.3
	12	-	0.1	0.9	0.7	0.2	0.5
	13	-	0.5	1.5	0.4	0.5	0.7
	14	2.6	2.1	1.9	1.9	0.4	1.4
	19	-	0.1	0.2	-	0.1	0.1
	Sharks	42.6	27.5	5.9	10.2	6.0	9.4
	40	0.9	0.7	2.3	1.2	0.6	1.2
	41	1.7	0.9	1.0	0.2	1.1	0.8
	Other fish	38.3	35.9	28.3	17.9	16.5	21.7
	Turtles	-	-	0.1	0.1	-	0.1
	n	115	1230	3463	3967	5169	13944
	sets	2	16	46	37	30	131

Table 7. Catch composition (% of total numbers caught) off SE United States, 1978-80 data combined.

Half of year	Spp.	Catch/1000 hooks <5	5-10	>10-20	>20-40	>40	All
1	1						
	2						
	3						
	4						
	5						
	6-9						
	10			(Samples too few)			
	11						
	12						
	13						
	14						
	Sharks						
	40						
	41						
	Other fish						
	Turtles						
	n						
	sets						
2	1	-	-	0.1	-	-	-
	2	9.4	15.6	17.4	8.4	4.0	9.1
	3	3.6	13.6	23.8	36.8	65.9	40.9
	4	-	-	0.1	0.1	0.1	0.1
	5	2.1	3.5	3.7	18.8	3.5	10.7
	6-9	-	0.1	0.4	0.2	0.1	0.2
	10	0.8	0.7	0.8	1.0	1.6	1.1
	11	0.8	2.0	3.4	2.5	3.0	2.8
	12	0.2	0.7	0.3	0.8	0.4	0.6
	13	-	0.6	1.1	1.1	0.5	0.9
	14	6.1	6.4	4.1	1.0	0.5	1.8
	19	-	0.1	-	0.1	0.1	0.1
	Sharks	36.3	24.4	22.7	13.4	9.4	14.9
	40	-	0.3	0.7	0.5	0.3	0.4
	41	0.4	0.8	1.0	0.8	0.8	0.8
	Other fish	40.5	31.1	20.5	14.4	9.7	15.6
	Turtles	-	-	-	-	-	-
	n	524	2116	5240	15084	9165	32129
	sets	13	38	68	115	54	288

Table 8. Catch composition (% of total numbers caught) off NE United States, 1978-80 data combined.

Half of year	Spp.	Catch/1000 hooks <5	5-10	>10-20	>20-40	>40	All
1	1	-	-	0.4	0.6	0.6	0.5
	2	-	5.8	10.9	17.9	22.1	17.8
	3	-	21.3	35.3	25.2	7.3	19.4
	4	-	-	-	0.1	0.2	0.1
	5	-	16.1	8.6	22.5	49.4	31.1
	6-9	-	-	-	0.3	0.3	0.2
	10	-	0.6	0.2	0.5	-	0.2
	11	-	1.9	0.9	0.5	0.1	0.4
	12	-	-	-	-	-	-
	13	-	0.6	0.2	-	0.1	0.1
	14	-	2.6	1.2	1.0	1.4	1.3
	19	-	-	-	-	-	-
	Sharks	-	23.9	18.0	16.2	7.8	13.1
	40	-	0.6	0.2	0.1	-	0.1
	41	-	0.6	0.1	0.1	0.1	0.1
	Other fish	-	25.2	23.9	15.1	10.8	15.5
	Turtles	-	0.6	0.2	-	-	0.1
	n	-	155	1269	1545	2412	5381
	sets	-	4	20	16	15	55
2	1	0.1	0.3	0.6	0.3	0.3	0.4
	2	6.5	15.3	21.4	24.9	16.2	19.6
	3	1.9	4.2	6.7	8.9	23.9	7.5
	4	-	0.1	-	0.2	-	0.1
	5	1.9	6.2	10.7	20.4	28.6	13.0
	6-9	-	0.1	0.1	-	0.2	0.1
	10	-	0.1	0.2	0.1	0.1	0.1
	11	3.0	1.3	0.9	0.5	0.3	1.0
	12	-	-	-	-	-	-
	13	-	-	0.1	-	-	-
	14	3.0	-	3.7	2.5	1.2	3.2
	19	-	-	-	-	-	-
	Sharks	48.2	32.9	24.9	20.7	17.1	26.8
	40	0.1	0.1	-	0.1	-	0.1
	41	0.1	0.1	0.1	0.1	-	0.1
	Other fish	35.2	35.1	30.5	21.4	12.0	28.0
	Turtles	-	0.1	-	0.1	-	-
	n	3167	8034	13548	11127	2397	38273
	sets	53	109	146	92	13	413

Table 9. Percent composition of the groupings "Sharks" and "Other fish."

1. Sharks

	Gulf of Mexico			Southeastern U.S.			Northeastern U.S.		
Spp.	1978	1979	1980	1978	1979	1980	1978	1979	1980
20	0.6	0.6	3.8	1.0	0.1	-	0.1	0.1	-
21	1.9	0.4	0.2	-	0.6	0.9	-	0.3	-
22	5.4	1.1	6.5	0.5	11.1	11.9	0.3	5.2	0.1
23	0.2	0.8	28.3	0.1	3.6	1.5	0.3	3.5	0.1
24	38.3	60.6	18.3	77.6	63.0	38.8	86.9	80.8	92.4
25	1.4	1.5	8.0	5.0	0.5	0.6	2.9	-	0.1
26	1.1	0.1	3.6	2.4	1.8	2.6	0.2	0.2	0.4
27	17.0	20.2	11.3	6.3	6.8	1.4	2.8	4.0	1.7
28	1.7	4.2	8.0	1.8	2.4	5.8	0.6	0.5	0.5
29	27.5	4.0	3.8	3.8	6.5	28.4	5.0	4.6	1.6
30	3.6	-	1.1	0.3	0.2	0.6	-	-	0.1
31	0.8	-	-	0.4	0.8	-	0.1	-	-
32	0.5	4.4	0.9	-	1.1	-	-	0.9	0.4
33	-	-	-	-	-	-	-	-	-
34	-	1.8	0.2	0.5	0.1	-	-	0.1	-
35	-	-	-	0.1	-	-	-	-	-
36	-	0.1	3.8	-	1.2	0.1	0.1	-	2.0
37	-	-	1.7	-	0.1	3.2	0.2	-	0.2
38	-	-	0.3	-	-	0.1	0.4	-	0.2
90	-	0.1	0.2	-	-	4.0	-	-	-
91	-	-	-	-	-	-	-	-	-
92	-	-	-	-	-	-	-	-	-
93	-	-	-	-	-	-	-	-	0.1
n	1150	1196	635	2001	1798	1077	2317	3872	5358

2. "Other fish"

40	19.9	0.6	3.3	0.5	4.1	0.9	0.2	0.2	0.2
41	7.1	2.3	1.8	7.2	5.7	2.0	0.1	0.4	0.2
42	6.1	0.3	0.4	7.3	1.5	2.7	0.6	0.2	0.2
43	42.8	54.9	54.0	44.9	64.7	64.3	36.1	51.9	62.9
44	4.5	4.6	5.4	7.0	11.1	7.3	14.5	7.5	7.2
45	0.5	1.8	19.0	1.6	0.7	2.0	1.6	1.1	1.3
46	2.9	1.7	-	0.6	0.4	0.6	5.3	1.6	1.5
47	11.3	25.6	9.0	23.5	7.5	14.6	38.3	31.4	21.7
48	0.1	-	-	0.7	0.3	1.3	-	-	-
49	2.9	6.2	6.0	6.7	3.6	3.9	2.1	2.6	4.0
50	-	-	0.1	-	0.1	-	0.1	-	-
51	0.1	0.1	-	-	-	-	-	0.2	-
52	0.3	1.7	0.9	-	0.2	-	0.8	2.8	0.6
53	-	0.1	0.2	-	-	-	-	0.1	-
54	1.4	-	-	-	-	-	-	-	-
55	-	-	-	-	0.2	-	-	-	-
56	-	-	-	-	-	0.2	-	-	-
57	-	-	-	-	-	0.1	-	-	0.1
58	-	-	-	-	-	-	-	-	-
59	-	-	-	-	-	0.1	-	-	-
n	1599	2174	1644	964	3058	1436	2004	2786	6831

Table 10. Numbers of sets with co-occurrences of various species pairs, and the results of association tests.[1]

Gulf of Mexico (587 sets)

Spp. co-ocurring 1978-80:

Spp.	1	2	3	4	5	10	11	12	13	14	Sharks
1	365	132^{-b}	255^{-*}	12^{c}	8*	47^{-*}	89^{-*}	20^{-*}	13*	262	281^{-*}
2		238	186	21	79*	41	68^{-*}	15*	22	179	195
3			451	35	75	97*	203*	64*	56*	324^{-*}	384
4				40	12	4	24	7	10*	28	35
5					91	17	47	10	19*	62	91*
10						111	78*	22*	19*	70^{-*}	104*
11							241	53*	50*	166^{-*}	206
12								67	18*	52	59
13									57	41	54
14										440	359
Sharks											492

Southeastern U.S. (286 Sets)

1	4	4	4	-	3	3	3	-	2	1	3
2		259	237	12	175	110	154	66	87	157*	257
3			262	16	180	123*	173*	72	99*	144	259
4				16	11	11	13	10*	10	6	15
5					192	113*	139*	62*	89*	93^{-*}	192
10						123	100*	52*	64*	48^{-*}	122
11							176	62*	87*	78^{-*}	174
12								78	42*	34^{-*}	77
13									99	36^{-*}	98
14										165	164
Sharks											283

Northeastern U.S. (460 Sets)

1	59	59	32	2	52	1	4^{-*}	-	-	52*	59
2		426	268*	21	361	23	98^{-*}	0^{-*}	5*	309	424
3			301	19	265*	24	93*	2	12	203^{-*}	301
4				24	22	2	6	-	2	16	24
5					384	23	92	2	10	277	384*
10						28	20*	1	2	13^{-*}	28
11							118	2	11*	68^{-*}	117
12								2	1	-	2
13									12	4^{-*}	12
14										329	327
Sharks											456

[1] In the Gulf of Mexico, e.g., there were 132 sets where species 1 and 2 co-occurred, 365-132 species 1 w/o sp. 2 sets, 238-132 sp. 2 w/o sp. 1 sets, and 587 + 132 - 365 - 238 sets with neither species. Translated into a presence-absence Chi-square interaction table, the association is found to be negative with $P < .01$.